ENVIRONMENTAL CONTEXT AND IMPLICIT AND EXPLICIT MEMORY

Ginni Lynn Guiton

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by

GINNI LYNN GUITON

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GINNI LYNN GUITON

Approved:

Major Professor

6-1-95

Date

Approved:

Dean of the Graduate School

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TABLE OF CONTENTS

Environmental Context and Implicit and Explicit Memory

Introduction

We have all had experiences in which we were on our way to perform a task and forgot what we were going to do until we returned to the original place, or environmental context, where we first decided to do the task. What is it that enables us to remember the task when we return to the original context? What cognitive mechanisms underlie contextual memory support? Does environmental context differentially affect various types of memory? Are there differences between the ways younger and older adults use environmental context to recall information? Does a change in environmental context between encoding and retrieval affect memory performance?

The relationship between environmental context and memory performance is of theoretical importance because it serves as an underlying assumption for many of the current theoretical models including the effects of memory activation and availability, the connection between current episodic context and what is studied, and the strength of association effects on the probability of recall (Bjork and Richardson-Klavehn, 1989).

The relationship between age and memory is also a widely studied phenomenon (Light and Singh, 1987; McIntyre and Craik, 1987). One of the most noteworthy findings in this body of research is that the decline

in memory ability is not consistent across conditions; it is very large under some conditions, but small or non-existent under others.

This study focuses on how the three components of age, environmental context, and memory interact; how, across the life span, context for to-be-remembered material affects memory. Of particular interest is determining whether there are differences in how young and old use contextual information, and how this use varies when tapping different types of memory. Understanding the use of context by older adults will enable to-be-remembered information to be contextually designed in the most effective manner for retrieval.

Definition of Environmental Context

A large body of literature addresses the environmental context effect and defines environmental context. For the purpose of this paper, I will use a combination of the best documented definitions. Thomson and Davies (1988) define environmental context as "the setting in which a target is found" (p. 2). This relatively basic definition is further refined by Smith (1988), who stated that context, although capable of being either intrinsic or extrinsic to the target information, is processed outside the focus of attention. He likens target, or focal, information to foveal vision, while contextual information is likened to peripheral vision. The fullest taxonomy of environmental context was developed by Bjork and Richardson-Klavehn (1989). They suggest that this construct may be defined by three characteristics: the relationship between the target and the context, the type of context, and the type of test at retrieval. Each of these components can be subdivided. The relationship between the target and the context may be integral, influential, or incidental; the type of

context is extra-item or intra-item; and the type of test at retrieval is either direct or indirect.

Park and Smith (1993) suggest further that context may be supporting or distracting, and they have identified three types of context instead of the two used by Bjork and Richardson-Klavehn (1989). For Park and Smith, context may be target-bound, extra-task, or extra-target/intra-task. They then place the relationship between target and context on a continuum from low to high. The present study will accept the definition of context stated by Bjork and Richardson-Klavehn (1989) while also incorporating the continuum and definition for type of context as introduced by Park and Smith (1993) because this provides the most precise definition.

Characteristics of Environmental Context

The first characteristic of environmental context concerns the relationship between target and context. Contextual information can be viewed as being placed on a continuum from incidental to influential to integral (Park and Smith, 1993). Incidental context, such as a room cue, does not influence the subject's interpretation of, or reaction to, the target material at encoding, but is encoded along with the target information (Bjork and Richardson-Klavehn, 1989). On the other end of the spectrum is integral environmental context, such as the stimulus word in a highly integrated word pair (e.g., sour GRAPES), in which the contextual stimulus is bound to the target stimulus. Because the sizeable effects of environmental context regarding influential and integral context are reliable and consistent (Bjork and Richardson-Klavehn, 1989), this end of the continuum is not relevant to the current research. The questions and debate lie on the incidental end of the continuum, where results regarding

environmental context vary widely (Fernandez and Glenberg, 1985; Smith, 1988; Bjork and Richardson-Klavehn, 1989).

The second characteristic of this construct involves the type of context; either extra-item or intra-item (Bjork and Richardson-Klavehn, 1989). This definition, as Park and Smith (1993) note, has a shortcoming. Although both the stimulus in a word pair and extraneous items in the subject's environment are considered to be extra-item, each has a different meaning to and impact on the subject. In order to adjust for this deficiency, Park and Smith (1993) have developed a more precise taxonomy. For these researchers, the type of context is either target-bound or extra-target; either intra-task or extra-task. Target-bound context involves the actual attributes of the target stimulus, including color, size, and other characteristics that are integral to the stimulus, but independent of the retrieval information. At the next level is the extra-target/intra-task type of context, in which focal information is spatially independent of the contextual information, although both focal and contextual information are presented by the experimenter. At the final, or extra-task level, external elements are present in the memory environment which are not presented by the experimenter (Park and Smith, 1993).

Most of the focus in previous studies incorporates a context type which is extra-task, in which subjects study information in one room and recall information in a different room, thus changing environmental context by changing rooms (Smith, Glenberg and Bjork 1978; Smith, 1979; Fernandez and Glenberg, 1985). In reviewing a comprehensive list of 29 published studies, Smith (1988) found 21 involved a change in room, or extra-task manipulation. Even with this number of studies, however,

Smith (1988) found no clear effects of environmental context in memory with 59% of the experiments showing an environmental context effect and 41% showing no effect (also see Bjork and Richardson-Klavehn, 1989).

Relatively unstudied is the type of context in which both focal and context information are presented by the experimenter but are spatially independent. Defined earlier as extra-target/intra-task, this construct may have more of an environmental context impact than the extra-task manipulation. Subjects in such a condition may be inclined to attend to both target and environmental context—to listen to and observe the experimenter's presentation—rather than to pay attention to some extraneous item such as a chair in the room (Park and Smith, 1993).

The third component that may be important in context effects is the type of test at retrieval. Instructions administered at retrieval play an important role in tapping different types of memory. These instructions can differentiate direct, or explicit memory, from indirect, or implicit memory. Under effortful direct retrieval conditions, participants are informed that they should try to retain information presented earlier in the study, whereas they are not asked to actively retrieve under indirect retrieval conditions (Bjork and Richardson-Klavehn, 1989; Park and Smith, 1993; Light, 1991). Age-related differences may be especially apparent in a direct memory condition, which emphasizes intentional or conscious recollection (Light, 1991; Park and Smith, 1993). In contrast, an indirect memory task, which involves unconscious recollection and decreased cognitive effort, is marked by fewer age-related differences and is thought to be relatively unaffected by age (Light, 1991; Light and Singh, 1987).

Task Characteristics

Data-driven tasks, such as word fragment completion tasks, utilize "bottom-up" processing, operate on perceptual information, and challenge the perceptual system. Target items are shown very rapidly or presented in degraded forms; and data-driven tests include word or picture fragment completion, word identification, or word stem completion (Roediger, Weldon, Stadler, & Riegler, 1992). Data driven tests are not sensitive to elaboration of study, but are sensitive to the match between modality, typeface, and study and test language; therefore it is the data-driven tasks that should manifest the most environmental context effects (Jacoby, 1994; Bjork and Richardson-Klavehn, 1989).

Conceptually driven tasks, which are based more on the meaning of events, involve "top-down" processing, which is constructive and semantically based. Subjects usually perform better on conceptual tasks with elaborate processing. Free recall is a conceptually driven task (Jacoby, 1994). Among conceptually driven tasks, more environmental context effects are noted in free recall than in cued recall tasks, and more environmental context effects are noted in cued recall than in recognition tasks. This continuum is identified by Smith (1988) as the "outshining hypothesis." In explaining the term, he states, "A heavenly body which is visible on a moonless night is more difficult to see when there is a full moon, and is completely outshone in the daytime by the sun" (p. 19). The analogy suggests that some cues to retrieval are weaker and less effective than others. For instance, if a powerful retrieval cue, such as the stimulus member of the paired associate, is available, it will dominate the retrieval task. In this case, a weaker cue, such as environmental context, plays a minor role in retrieval (Bjork and Richardson-Klavehn, 1989).

Empirical Studies Examining the Effects of Environmental Context

In 1975 and 1980, Baddeley conducted context-dependent studies with deep-sea divers. The divers were asked to encode passages of prose and lists of unrelated words underwater and to perform either a recall or a recognition retrieval task on dry land. Baddeley found a decrement of 30% in the number of words remembered in the different environment recall condition compared the same environment recall condition, but no decrement in the recognition conditions. This result is an example of the outshining hypothesis theory in that the environmental context effect depended upon the strength of the environmental context cues relative to other cues present; therefore, the environmental context effect is rarely observed when memory is tested by recognition (Baddeley, 1982; Smith, 1988). Baddeley (1982) felt that the environmental context is encoded independently and in parallel with the item to be remembered. In other words, the interpretation of a set of words in his experiment did not depend on the location where they were experienced, whether on land or in water. However, recalling in the same environmental context may enhance the accessibility of the memory trace imprinted during encoding (Baddeley, 1982).

Two drawbacks inherent in a majority of the studies previously conducted are the use of general context and the establishment of environmental context as a between-subjects variable (e.g., subjects either physically move to a different room, remain in the same room, or move to a neutral room) (Bjork and Richardson-Klavehn, 1989). In general context encoding, the context is included in many item encodings, while in specific context encoding, it is included in only one or a few item encodings (Smith, 1988). Changing the environmental context with each

encoding pair may have a profound effect, or at least a different effect, on retrieval with reinstatement of the same environmental context (Smith, 1988). If many episodes occur in the presence of the same environmental context cues, cue-overload may occur, and the effectiveness of the cues will diminish (Bjork and Richardson-Klavehn, 1989).

In a three-day study conducted by Smith, Glenberg, and Bjork (1978, Experiment 2), environmental context was a within-subjects variable and both general and specific context were studied using weakly associated word pairs. The results were dramatic. One group, tested on day three at the location where they learned the words on day one, remembered 31% more responses for common cues and 34% more responses for unique cues for day one word pairs than did groups that were not tested in the same location. Another group was tested on day three for the words they learned on day two; both sessions were held in the same location. This group recalled 28% more common cues and 12% more unique cues than did the other two groups that were tested in another location. Bjork and Richardson-Klavehn (1989) recommend further study of environmental context using a within-subjects design, which may enhance the nuances of the environmental context effect and reduce the effects of individual differences.

If subjects are able to mentally reinstate the encoding environment, the chance that environmental context effects will occur is reduced (Bjork and Richardson-Klavehn, 1989; Smith, 1988). Smith (1979) and others (Fisher, Geiselman, Holland, and MacKinnon, 1984) demonstrated that subjects in certain conditions are able to mentally reinstate the original context and enhance performance. One may conclude, in the words of Bjork and Richardson-Klavehn (1989), that "only in those situations in

which imaginal reinstatement is difficult or impossible should we expect reliable effects of physical reinstatement" (p. 333). Park and Smith (1993) propose that these effects might be generated by creating unique backgrounds, or environmental context, for each item to be encoded. Such a technique would not only make mental reinstatement of environmental context almost impossible, but also would incorporate a within-subjects design which should be more sensitive to environmental context.

Differences Among Age Groups

There are two hypotheses relative to environmental context which are concerned with the elderly and declining performance: the inhibition hypothesis (Hasher and Zacks, 1988) and the resource-capacity hypothesis (Craik, 1986).

The central assumption of the inhibition hypothesis with respect to aging is that

> the efficiency of the inhibition processes that underlie selective attention is reduced. This decrement in inhibition allows more irrelevant information to enter working memory, and once entered, it allows the irrelevant information to receive sustained activation. This then sets the stage for subsequent reduced rates of success in accessing required information from memory. (Hasher and Zacks, 1988, p. 219)

According to this theory, active storage, rather than processing, is where the elderly differ from the young. Hasher and Zacks suggest that the elderly compensate for the increased amount of irrelevant information available at retrieval by relying on information that is in the surrounding environment and is easily accessed from memory. Therefore,

environmental context has greater impact on the elderly, who also respond more favorably than the young to contextual reinstatement.

In contrast to Hasher and Zacks, Craik (1986) contends that the elderly encode more superficially and are less apt to engage in deep semantic processing. Craik argues that as the requirements for self-initiated operations increase and environmental support decreases, the age-related decrement increases. McIntyre and Craik (1987) performed a study in which the elderly and the young were asked to state the mode of presentation of known facts one week after the initial presentation. The elderly performed only at chance level (.50), whereas the young demonstrated some memory for modality (.59). McIntyre and Craik (1987) argue that the decreased ability of the elderly to recall the source of a known fact may be associated with a more general failure of older subjects to integrate focal events with their contexts of occurrence.

The resource capacity hypothesis, as espoused by Craik (1986), suggests that older adults are less able than younger adults to encode the environmental context because of the self-initiated processing involved; therefore, they do not demonstrate a significant difference between same and different context. Younger adults, on the other hand, have sufficient working memory capacity to encode the environmental context and demonstrate larger environmental context effects.

Purpose of the Present Study

This study seeks to compare the relationships among age, retrieval type, and environmental context within the framework of comparing both the resource-capacity hypothesis and the inhibition hypothesis. It incorporates the lessons learned from previous studies in order to develop an experiment which optimizes the possibility for the occurrence of

environmental context effects while examining different memory systems. The relationship between target and context, the type of context, and the type of test at retrieval are examined, as well as the differences between data and conceptually-driven tasks, implicit and explicit memory, and age.

The incidental relationship between target and context, and the extra-target/intra-task type of context remained constant throughout the study. In order to achieve this focus, a computer program was used to generate an incidental contextual background for a series of word pairs. This context type creates a specific environment for each item encoded and allows context to be a within-subjects variable, thereby sensitizing the study toward environmental context. In addition, it allows for the use of a background recognition task to determine subject sensitivity towards environmental context.

Type of retrieval was varied across conditions by task characteristics, data-driven versus conceptually driven; and measures of memory, explicit versus implicit. One condition retrieved using the conceptually driven task of cued recall; the other two conditions retrieved using a data-driven, word fragment task. Two of the three conditions retrieved after receiving explicit instructions; whereas the third retrieved under implicit conditions. The cued recall condition was explicit. One of the word fragment groups was explicit, whereas the other was implicit. This created three conditions for each age group: cued recall-explicit, fragment completion-explicit, and fragment completion-implicit.

In addition to examining two age levels and three retrieval types as between subjects variables, the study uses two types of encoding: intentional and incidental. In intentional encoding, the subject is told ahead of time that the information will be tested later; in incidental

encoding, the subject is not given these instructions. The cued recall condition was intentional. One of the fragment conditions was intentional, while the other was incidental.

In general, young subjects are expected to perform better than older participants; subjects in the conceptually driven cued recall conditions are expected to outperform those in the data-driven word fragment conditions; subjects in the explicit conditions should perform better than subjects in the implicit condition. According to the resource capacity view (Craik, 1986), environmental context has a greater effect of retrieval ability on the young; conversely, the inhibition view predicts a greater effect of retrieval ability on the elderly (Hasher and Zacks, 1988).

The following results are hypothesized: The cued recall-explicit condition will show the greatest age disparity because encoding is intentional and retrieval is explicit; so, even though retrieval is cued, there is less environmental support, the requirements for self-initiated processing increase, and therefore age effects increase (Light & Albertson, 1989; Craik, 1986). Due to the fact that retrieval in this condition is a conceptually driven task, overall proportion correct will be higher than either of the data-driven conditions. Additionally, results will likely demonstrate fewer environmental effects than the other two conditions because this task is conceptually driven and encoded intentionally; thus the environmental context cue is outshone by the word pairs. Because environmental context effects are not expected, neither Hasher and Zacks (1988) nor Craik's (1986) theory regarding the effects of environmental context applies for the cued recall condition.

The word fragment-explicit condition should show fewer age related differences, because it is a priming, or activation, task which requires less

self-initiated processing and provides more environmental support than the cued recall task; however, retrieval is explicit and encoding is intentional which taps a memory system in which the young consistently outperform the old (Light & Singh, 1987) so significant age differences could occur. Because this task is sensory in nature it has the potential for more environmental context effects than the cued recall condition. Although Craik (1986) had concluded that young subjects would demonstrate the greatest environmental context effects, the research of Hasher and Zacks (1988) supported an opposite conclusion: old subjects showed the most environmental context effects.

The word fragment-implicit condition is expected to show the least age effects, because conscious recollection is not required and implicit memory does not decrease as much with age (Light & Singh, 1987; Light & Albertson, 1989) and activation, or priming, tasks which provide the most environmental support. Also, because of the incidental encoding, this condition will generate the greatest environmental context effects. Again Hasher and Zacks (1988) predict the elderly can be expected to show the most environmental context effects, while Craik (1986), on the other hand, anticipates the opposite result.

Method

Design

The present study examines two age groups and three types of retrieval as between subjects variables. The two types of environmental context are within subjects variables. The analysis of variance was used to study two levels of age (Young vs. Old) × three retrieval types (Cued Recall vs. Fragment-Explicit vs. Fragment-Implicit) × two types of environment context (Same vs. Different).

Participants

A total of 144 participants was tested: 72 undergraduate students from the psychology research pool at the University of Georgia, and 72 community dwelling adults. The young participants (mean age of 19.78 years, 13.5 years of education) were enrolled in psychology courses and received course credit for their participation. Ninety percent judged themselves to be in good or excellent condition regarding their health, and were averaged less than one (.62) prescribed medication. Elderly subjects (mean age = 70.9 years, 16.6 years of education) were paid $15.00 each for their participation in the study. Regarding their health, seventy-eight percent felt that they were in good or excellent condition, and this group was taking an average of 2.4 prescribed medications per day. All participants had normal or corrected-to-normal vision. Participants were tested in small groups ranging from one to six people per group. Additional demographic information regarding the subject pool appears in Table 1.

Materials

Encoding lists. Eighty concrete nouns were selected from lists drawn up by Erickson, Gaffney, and Heath (1987) and Gibson and Watkins (1988). The words used from these lists had a frequency of 50 words per million or less, according to Thorndike and Lorge (1944). Norms for related word pairs were collected in a previous experiment from 16 undergraduates from the University of Georgia and Georgia Institute of Technology. These students were given the list of 80 words and instructed to write down the first ten concrete nouns (of six to eight letters each) that came to mind. Of the 80 word pairs created by the students, 32 context/target pairs were selected for the current experiment.

These word pairs had to fit the following criteria: Each associate was a concrete noun which had been generated by 12.5-25% of the participants and had a frequency of 50 words per million or less, as defined by Thorndike and Lorge (1944).

The encoding lists were arranged so that half of the target words for the word pairs were derived from Erickson, Gaffney, and Heath (1987) and Gibson and Watkins (1988), and half of the target words were generated by the Georgia students. This list was then counterbalanced to create two lists: List A and List B. Each target word was counter-balanced, so that all words served as both associate and target words across both lists.

Word fragments were drawn from Gibson and Watkins (1988) and Erickson, Gaffney, and Heath (1987). Letters were added so that although 40-50% of the letters were provided in each fragment, the fragment still had a unique solution according to the Kucera and Frances (1967) program. The same program was used to establish fragments for the words generated by the Georgia students. A baseline rate for word fragments was normed to establish consistency across both conditions. All word pairs were then randomized.

The word pairs were presented against a unique pictorial background. The background served as the context manipulation. Backgrounds were selected from the PhotoDisc Multimedia Sampler, Volumes I-IV. They were chosen based on the following criteria: the pictures did not depict people or animals, they were not generally emotionally charged (e.g., no Three Mile Island or similar scenes were used), and they did not relate to the word pair (e.g., the words, "azalea blossom" would not be superimposed on a background picture of flowers).

Thus only incidental relationships existed between the word pairs and environmental encoding. In addition, backgrounds had to be selected that were consistently darker in the middle portion, so the participants could easily see the white lettering of the word pairs. All word pairs were superimposed on the backgrounds using Aldus Persuasion 2.1. (See Appendix A for a description of the pictures used.)

Retrieval Lists

During the retrieval phase, all 32 of the word pairs were seen on the pictorial backgrounds that were used in the encoding task. However, 16 of the word pairs were viewed on the same background upon which that specific pair had been superimposed during the encoding task. The other 16 word pairs were seen on a different background than had been used for that particular pair during the encoding task. These backgrounds then were new to the word pair, but not new to the study. The backgrounds were randomized and placed with new word pairs, and the entire list was again randomized. No more than three same or different environmental context slides were placed in a row. A test was also constructed to determine the subjects' memory for the backgrounds. In this background recognition task, 20 backgrounds, without any superimposed word pairs, were used. Ten of these had been seen in the encoding and recall tasks and ten were new to the subjects. New backgrounds were chosen following the criteria used for the original backgrounds. Again, a random numbers chart was used to determine the presentation order.

Procedure

Subjects were tested in a room in the Psychology Building at the University of Georgia. All subjects were randomly assigned to retrieval condition and tested in groups ranging from one person to six people.

Stimuli in the encoding, distractor, retrieval, and background recognition tasks were presented on a screen via an overhead projection panel using the Aldus Persuasion 2.1 program. All subjects received the same encoding list of 32 items. The two groups who were in the intentional conditions were told at that time, "Pay close attention to what is presented on the screen. You will be tested on it later." The participants in the incidental condition were not informed that they would be tested on the information. Subjects were given five seconds to rate each of the 32 word pairs for relatedness. They were asked to rate each word pair by drawing a circle around the appropriate number on the paper, using a scale in which 1 = unrelated and 7 = strongly related. This requirement forced the subjects to attend to both the target and the context words.

Two distractor tasks were then administered, with the same distractor tasks being assigned to all three retrieval conditions. The first distractor task consisted of rating girls' names for pleasantness. In this assignment, girls' names were presented one at a time on the screen and the participants were given seven seconds to rate each one. The second was a definition task in which short definitions were presented one at a time on the screen and subjects were asked to write the three- or four-letter word that best fit the definition. Because environmental context effects are more likely to appear after a longer duration of time (Smith, 1988; Bjork and Richardson-Klavehn, 1988), these tasks were designed so

that a period of time elapsed between the encoding and recall conditions. Both tasks, including the instructions, took approximately 13 to 15 minutes.

In the retrieval task, two groups responded after receiving explicit instructions, while one group responded without receiving such instructions. In the first condition, subjects were explicitly told to write down the word that matched the cue word in the encoding task; this was labeled cued recall-explicit. In the second condition subjects retrieved word fragments under implicit conditions; no reference was made to earlier exposure. This group was labeled fragment-implicit. The third condition consisted of subjects who were intentionally instructed before encoding; this group performed a word fragment retrieval task under explicit conditions and were labeled fragment-explicit. These participants were told that all the word fragments they were trying to complete had been seen in the encoding task. Subjects across conditions were given ten seconds to record each answer. Because the cues and fragments were timed by the computer, the participants were unable to return to a previous question once it had passed.

The background recognition task was administered in a similar manner. The backgrounds were presented one at a time on the screen. The subjects had five seconds to circle a "yes" if they had seen the background previously in the study, or "no" if they had not seen the background earlier. This task tested the discriminability of the subjects to the environmental context. Two scores were derived from this task. This first score is referred to as the hit rate. A correct answer for a previously seen background, or a "yes" response to a "yes" background, was considered a hit. The total number achieved is the hit rate. An

incorrect answer for a new background, or a "yes" response to a "no" background, was considered a false alarm. The total number answered in this manner was the false alarm rate. The estimate of discriminability, or d', was calculated by subtracting the standardized score for the false alarm rate from the standardized score for the hit rate.

A measure of working memory, listening span, was then administered. It was orally presented by playing a pre-recorded tape. Subjects were asked to answer questions while remembering the final word of each sentence, beginning with one and ending with six sentences. There were three sets per level. Two scores were calculated for each subject: a trial score and a span score. The trial score consisted of the number of questions answered correctly per set, while the span score was the total of words correctly recalled at each level per set. Recall was defined as the number of levels passed with at least two of the sets in that level correct.

The next task was a letter comparison task in which two strings of letters were presented. The strings had either three, six, or nine letters each. Subjects were asked to write an "S" if the letter strings were the same, or a "D" if they were different. Thirty seconds per page was allotted. The number correctly written was counted for each page and then the three numbers were added together for a total perceptual speed score.

The next item was the vocabulary portion of the Shipley Institute of Living Scale (1940). Forty vocabulary items were presented. Subjects were instructed to circle one out of four multiple choice items which had similar meanings or nearly similar meanings as each item was presented

and to guess if they did not know the correct answer. Their score was the total number of items correctly circled.

The last item was a demographics questionnaire. For this item, subjects rated their general health and how it compared to others of the same age. Subjects were also asked their age, race, gender, and number of prescription medications they were currently taking, as well as their level of education, marital status, and whether or not they were living alone.

Results

Two analyses of variance were conducted. The first was a 2(Age: Young vs. Old) × 3 (Retrieval Type: Cued Recall—Explicit vs. Fragment—Explicit vs. Fragment-Implicit) × 2 (Environmental Context: Same vs. Different) analysis in which the dependent variables were the proportion of correct items. Two scores were calculated for each subject; both measured the number of target words correctly identified. The environmental context in encoding and retrieval was the same in one score and different in the other.

Analysis of Environmental Context

A significant main effect of age was found (F (1, 138) = 91.08, $p < .0001$) with the young performing significantly better than the old (.474 vs. .240). There was also a main effect of condition (F (1, 138) = 80.44, $p < .0001$) with subjects in the cued recall condition (.577) performing significantly better than those in the fragment-explicit condition (.249) and fragment-implicit condition (.246). Varying environmental context in the retrieval condition had no significant effect (F (1, 138) = 2.34, $p = .128$), means equalled .367 and .348, respectively (Figure 1).

There was an age × condition interaction (F (2, 138) = 12.27, p < .0001). Simple effects analyses were performed which determined that the age differences in the cued recall condition were significantly greater than the fragment-explicit condition (F (1, 92) = 12.30, p < .0007) or the fragment-implicit condition (F (1, 92) = 17.75, p <.0001), but the comparison of the two fragment conditions did not yield significant results (F (1, 92) = .98, p < .32). No other main effects or interactions were significant (Figure 2).

Analysis of Background Recognition

The second analysis was a 2(Age: Young vs. Old) × 3(Retrieval Type: Cued Recall—Explicit vs. Fragment—Explicit vs. Fragment—Implicit) ANOVA in which the dependent variable was d', or the subjects' discrimination ability. As stated earlier, this variable was calculated by subtracting the standardized score for the false alarm rate from the standardized score for the hit rate. There was a significant difference in age, with young performing better than old, for d' (F (1, 138) = 3.17, p < .05) across conditions, with standardized mean scores of young versus old of 1.41 and .891. This was due to the younger subjects outperforming the elderly in the retrieval task. Mean hit rate for young and old was .589 vs. .479, while the false alarm rates were much closer with raw proportion scores of .239 vs. .231 (Figure 3).

Correlations

The proportions that were correct for same environmental context and for different environmental context were correlated with the cognitive measures. In total, nine separate correlation matrices were performed. There was an overall matrix for each retrieval condition with 48 subjects per matrix. These three matrices each had two sub-matrices, one for old

subjects and one for young subjects with 24 subjects per matrix. Correlations were considered significant if they had a probability of less than .05 using Pearson's Correlation Coefficient.

Of primary interest is the correlation of the dependent variables with the cognitive variables. For the most part, in the three matrices with ages combined, the cognitive variables all correlate to a similar degree and in the same direction with the proportion correct for the same and different environments. Therefore, the better the participants performed on the cognitive variables, the better they performed on the dependent measure. Listening span correlated with environmental context as follows: cued recall: same, ($r = .33$, $p = .020$); different, ($r = .41$, $p = .003$); fragment-explicit: same, ($r = .32$, $p = .025$); different, ($r = .27$, $p = .056$); fragment-implicit: same, ($r = .21$, $p = .139$); different, ($r = .31$, $p = .031$). These results support the view that the cued recall task involves more working memory, whereas the fragment conditions, which did not correlate as strongly, involve more of an activation process for retrieval. Perceptual speed correlated with environmental context as follows: cued recall: same, ($r = .33$, $p = .0001$); different, ($r = .75$, $p = .0001$); fragment-explicit: same, ($r = .50$, $p = .0003$); different, ($r = .27$, $p = .058$); fragment-implicit: same, ($r = .39$, $p = .005$); different, ($r = .51$, $p = .0002$). This again lends support to the view that fragment completion is a memory activation process; the fragment conditions did not correlate as strongly with perceptual speed.

Of secondary interest is the correlation of the cognitive variables with each other (mean scores for the cognitive variables are listed in Table 1). The results here were consistent with those of other studies. The Shipley vocabulary score and listening span working memory task

were negatively correlated across conditions: cued recall, ($r = -.26$, $p = .071$); fragment-explicit, ($r = -.37$, $p = .009$); fragment-implicit ($r = -.04$, $p = .754$). The overall mean scores for vocabulary for young and old were 30.0 and 35.2 respectively, whereas the mean scores for the working memory task were 4.15 and 3.02, causing the negative direction. This result supports the general theory that our memory for vocabulary is crystallized and remains constant as we age, but our working memory capacity decreases.

Listening span and perceptual speed were significantly correlated across conditions: cued recall, ($r = .31$, $p = .02$); fragment-explicit ($r = .51$ ($p = .0002$); fragment-implicit, ($r = .36$, $p = .01$). This outcome demonstrates that the young have better working memories and are faster at their tasks. The raw score means for young and old in perceptual speed were 47.07 versus 32.43.

A significant negative correlation resulted in all three conditions with a comparison of speed and vocabulary: cued recall, ($r = -.28$, $p = .05$); fragment-explicit, ($r = -.55$, $p = .0001$); fragment-implicit, ($r = -.42$ $p = .003$). As demonstrated earlier, the young were faster than the elderly with means of 47.07 versus 32.43, while the elderly performed better on the vocabulary task, with means of 30.0 for young and 35.2 for the elderly.

Because the sample sizes for the sub-groups are smaller, the number of significant correlations is much smaller. Same and different environmental context significantly correlated with each other across conditions but did not correlate with the cognitive variables.

Discussion

What are the implications of these results for understanding the relationship among age, context, and memory? How can this information assist in designing context to provide support for the elderly regarding retrieval of to-be-remembered items? Overall in this study, the young performed significantly better than the old. Task type had an effect, and retrieval conditions with more environmental support assisted the elderly's performance; tapping the explicit memory systems did not consistently aid in retrieval across conditions; and environmental context did not have a significant effect on young or old in any condition. What does all of this mean?

These data reinforce findings by other researchers which suggest that decline in memory is not constant across different memory systems. Although the elderly performed worse than the young for all conditions, the cued recall-explicit condition had a significantly greater gap between age groups. Two different components are relevant in this finding: the differences between age groups with either explicit or implicit instructions, and the differences between age groups with varying amounts of environmental support.

Two conditions, cued recall and one fragment condition, received explicit instructions, whereas one fragment condition received implicit instructions. As shown by the simple effects analysis, the delta between age groups in the cued recall condition was significantly different than the delta between age groups in the fragment-implicit condition. This confirms findings by other researchers that incorporating direct, or explicit, retrieval demonstrates greater age differences than incorporating indirect, or implicit retrieval (Light & Singh, 1987; Light and Albertson,

1989). However, if explicit retrieval consistently shows greater age effects than does implicit retrieval, why are there no significant differences between the two fragment conditions? This can be explained by examining the environmental support provided, and the memory system tapped to retrieve the information.

Even though subjects in one word fragment condition are explicitly told that they have seen the words before, it is extremely difficult to recall the 32 words seen in the encoding task and superimpose them on the word fragment shown by the experimenter. In the word fragment tasks, memory activation, or priming, occurs. The word suddenly comes to the subject. Unlike in the contextual recall condition, knowledge that they have seen the words earlier in the study does not provide the same benefit. However, in the fragment conditions, the amount of environmental support provided is high, therefore the amount of self-initiated processing decreases, and the differences between the two age groups decreases. For the cued recall task, although a cue word is presented, less environmental support is provided, conversely increasing the amount of self-initiated processing, and increasing the differences in performance between age groups. It is the combination of explicit instructions and lack of environmental support which causes the largest age differences in the cued recall condition. These data reinforce the view that not all memory is the same; we may have multiple memory systems which are affected to different degrees by the aging process (Light & Albertson, 1989; Light & Singh, 1987; Craik, 1986).

The second result which yielded significant differences is that of task-type, or the data-driven versus the conceptually driven dimension. Those subjects in the cued recall condition who were able to use the "top

down" processing of the semantically based stimulus word to determine the target word performed significantly better than those subjects in the word fragment conditions who had to rely on the "bottom up" processing of activation, or priming, required for fragment completion; although, as stated earlier, the cued recall task did require more self-initiated processing. The elaboration task of relating the context and target for relatedness assisted subjects in the conceptual cued recall condition more than it assisted subjects in the data-driven word fragment conditions. This reinforces the belief that conceptual tasks are sensitive to elaboration of processing at study, but data-driven tasks are not (Bjork & Richardson-Klavehn, 1989; Light & Albertson, 1989).

The lack of environmental context effects in any condition was a rather disappointing finding. These effects were not expected in the cued recall condition, because the intentional encoding and explicit retrieval outshone the weaker retrieval cues of environmental support. However, it was hypothesized that environmental context effects would appear for the word fragment conditions, due to the data-driven nature of the task and the fact that one condition retrieved implicitly. This did not occur.

The lack of effects creates difficulty in mapping either the inhibition hypothesis or the resource capacity hypothesis onto the results. The inhibition hypothesis states that the elderly are better aided by contextual reinstatement and predicts same versus different environmental background has a larger effect on this age group. The resource-capacity hypothesis states that the elderly encode superficially and do not have the working memory capacity to encode incidental information, and predicts that same versus different environmental context would have a larger effect on the young. Two findings both lend

support to Craik's (1986) resource-capacity hypothesis and detract from Hasher and Zacks (1988) inhibition hypothesis. First, the young performed significantly better regarding d', or the estimate of discriminability. They were more aware of the backgrounds they had previously seen, and therefore, had encoded the backgrounds to a greater degree than the old. Second, the old showed no environmental context effects in any condition, which undermines the view espoused by Hasher and Zacks (1988) that the elderly are unable to inhibit irrelevant information and will rely on easily accessed information, such as context to compensate for the increased amount of information in working memory. The reinstatement of the environmental context used at encoding did not assist the elderly with retrieval.

What were the limitations of this study which might have negated the fragile effects and weak retrieval cue of environmental context? Where can future studies build on this foundation, so that we can better understand how context can assist the elderly with retrieval? An issue with the current study is the intentional encoding used in the cued recall and one of the fragment conditions. Not only did this prevent the direct comparison between the two fragment conditions due to the difference in both encoding and retrieval, but also this may have negated, or at least diminished, the environmental context effects. These explicit instructions were not given in the implicit word fragment condition, and it was this condition, with the data-driven task and incidental encoding that was predicted to show the greatest environmental context effects. However, even in this condition, no environmental context effects were evident.

It is possible to alter several variables in future studies to further understanding of context. The first variable which could be altered is the

amount of time allowed for the encoding task. Perhaps five seconds was not enough time for the elderly to process and record the strength of the relationship between the stimulus and target of the word pair. This might have enabled the elderly to retrieve more target words across conditions, and enabled them to better process the background. This might achieve more of an environmental effect. It is also possible that testing subjects individually at the computer would yield more effects of environmental context. Background resolution is slightly degraded when magnified onto a large screen, and this small loss in clarity might further diminish the already weak effect of environmental context.

Another variable which may need to be altered to produce environmental context effects is the length of time between encoding and retrieval. Smith (1988) notes that presentation time, retention interval, level of processing, and sensory modality of presentation continue to have unknown effects on environmental context. It may be that one of these variables has to be altered to produce environmental context effects.

In future research, this experiment can be varied, building upon this technique of environment manipulation and adding to our understanding of the effect of environment on memory processes across the life span. Testing a fragment-explicit condition in which encoding is incidental would allow for a direct comparison between explicit and implicit fragment conditions. This cannot be done with the current word fragment conditions because both encoding and retrieval differ, creating a confound. A condition in which both the cue word and the word fragment are present could continue to broaden our knowledge base. This would allow us to examine how performance differs across the life span when both contextual and data-driven support are provided.

In sum, this study helped further understanding of how memory, age, and environmental context interact. It examined how young and older age groups are effected by data driven versus conceptually driven tasks; how explicit and implicit memory systems are differentially influenced by the aging process; and how both environmental context and support relate to aging and memory. It built upon the foundation that was laid by previous researchers and provided opportunities for future studies. With the entire body of research, contextual supports can be devised and emplaced in order to fully assist the elderly with retrieval of to-be-remembered items. This will enable the aged to function better in everyday tasks, and improve quality of life for all.

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Table 1
Mean Scores for Cognitive and Health Variables

Variable	Mean	
	Young	Old
Cognitive		
Listening Span	4.15	3.02
Perceptual Speed	47.07	32.43
Shipley	30.00	35.24
Health		
Perceived Health	1.81	1.94
Prescriptions	.63	2.40

Figure 1. Age × Condition Interaction. The dependent variable is defined as the proportion correct collapsed across environmental context.

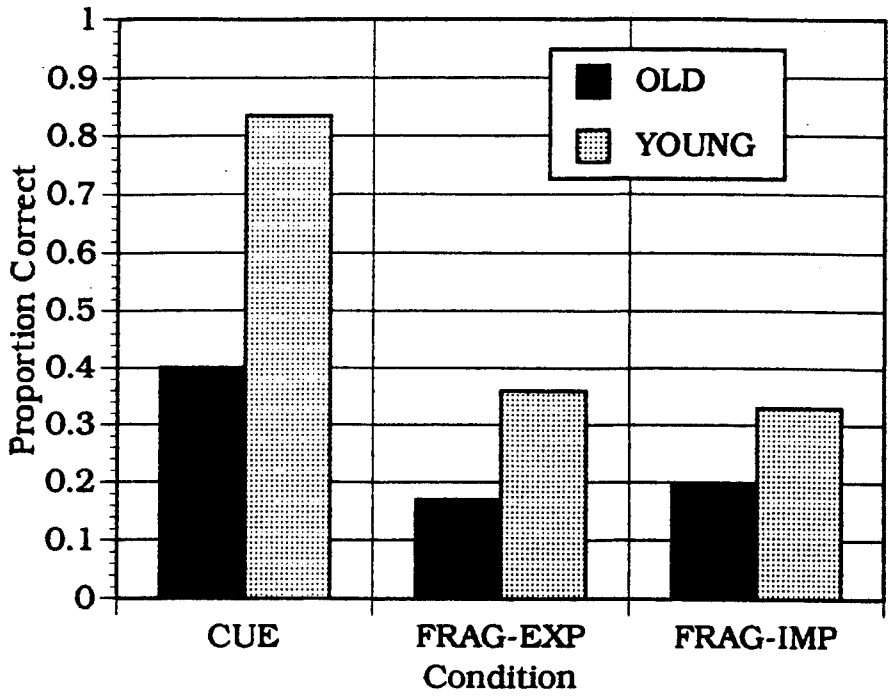
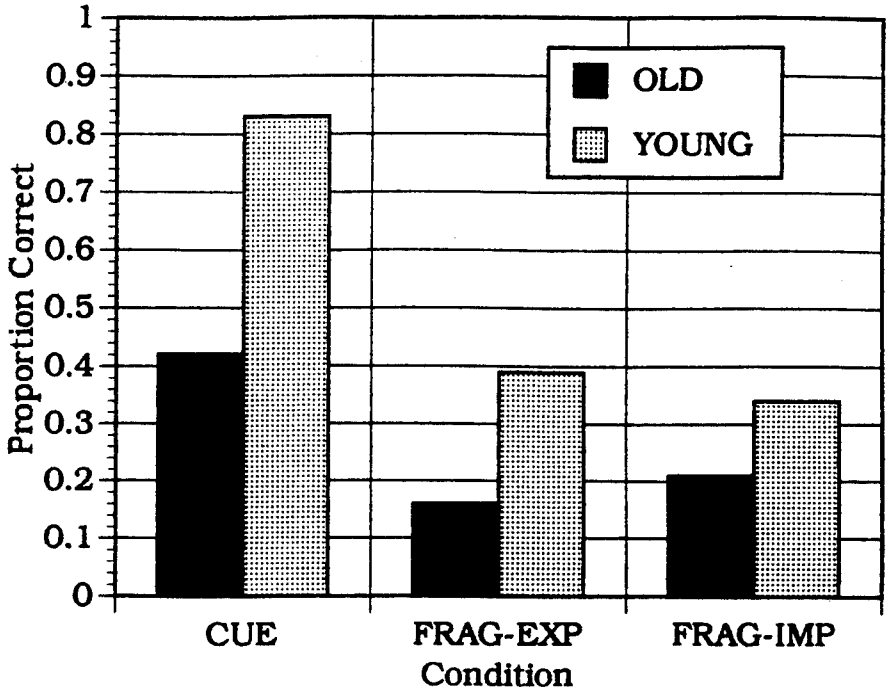

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion Correct
OLD
YOUNG
CUE
FRAG-EXP
FRAG-IMP
Condition

Figure 2. Age × Condition x Environmental Context Interaction. The dependent variable is defined as the proportion correct for same environmental context and for different environmental context.

same environmental context



different environmental context

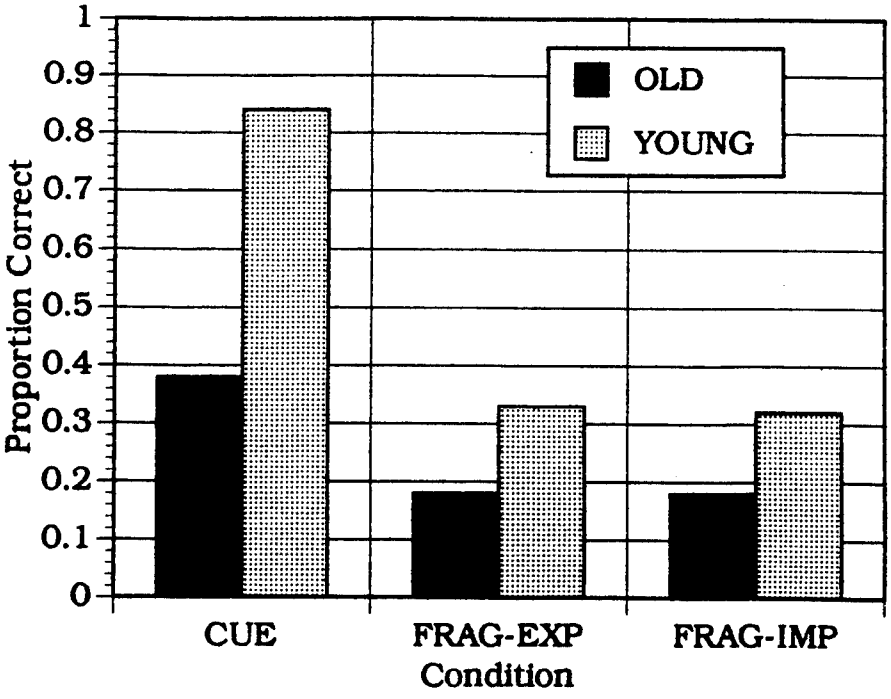
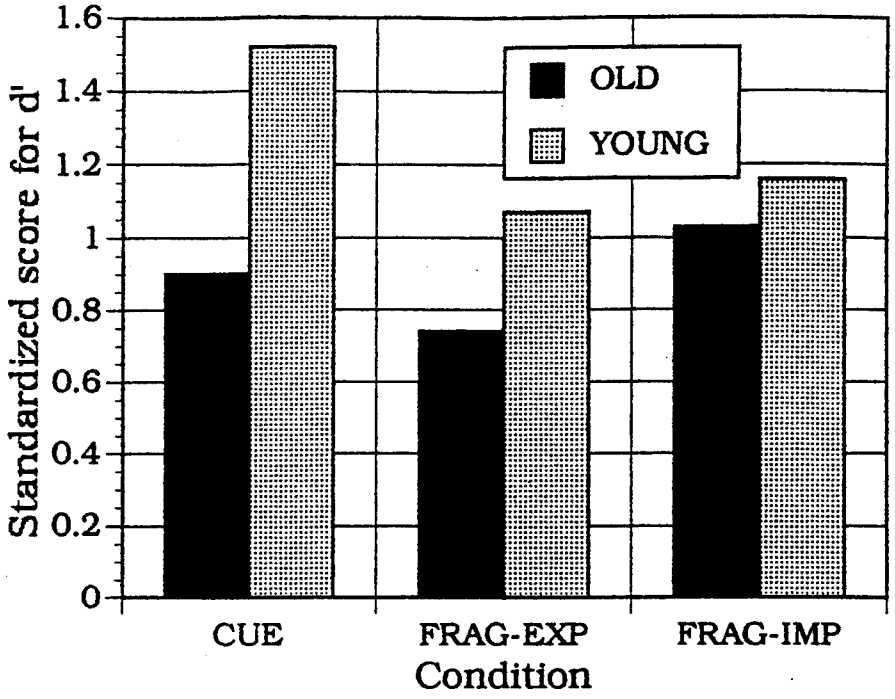


Figure 3. Age × Condition Interaction. The dependent variable is d'.


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Standardized score for d'
OLD
YOUNG
CUE
FRAG-EXP
FRAG-IMP
Condition

Appendix A

Encoding, Retrieval, and Background Stimuli

Encoding List

	Word Pair	Encoding Number & Background
1.	swimmer undertow	003.tif(1:1) San Francisco Sky
2.	auction antique	279.tif(1:1) Lighthouse
3.	anthill aardvark	034.tif(1:1) Sunset from Mt Pass
4.	cookie spatula	IV016.tif(1:1) Mt Saint Helens
5.	azalea blossom	175.tif(1:1) Vineyard through Trees
6.	pharaoh mummies	111015.tif(1:1) Water Lilies
7.	pavement driveway	122.tif(1:1) Washington Sunset
8.	chimney bricks	11251.tif(1:1) Fireworks
9.	bookbag knapsack	160.tif(1:1) Construction
10.	sapphire necklace	11275tif(1:1) Barn and Windmill
11.	nutmeg eggnog	020.tif(1:1) Poppies and Lupin
12.	sheriff handcuff	091.tif(1:1) Endgrain
13.	fabric scissors	287.tif(1:1) Lightning III
14.	warranty repair	006.tif(1:1) Calla Lily Foliage
15.	cemetery zombie	111075.tif(1:1) Beech Trees
16.	headache stress	305.tif(1:1) Moon
17.	guitar rhythm	119.tif(1:1) Cloverleaf Highway
18.	kingdom princess	11107.tif(1:1) Roses in the Rain
19.	recline armchair	11120.tif(1:1) Tulips in Sun
20.	income taxpayer	404.tif(1:1) Telephone Poles
21.	muscles athlete	004.tif(1:1) Budded Poppy
22.	washbowl bathroom	11237.tif(1:1) Tulips in Vase
23.	kerosene gasoline	325.tif(1:1) Airplane
24.	fireman hydrant	106.tif(1:1) Satellite Antennas
25.	blanket flannel	214.tif(1:1) Sprinkler Array

26.	runway airport	283.tif(1:1) Seattle Skyline
27.	inferno volcano	111007.tif(1:1) Chainlink Fence
28.	quartet singers	111101.tif(1:1) Sugauro Cactus
29.	painting mosaic	015.tif(1:1) Lone Tree
30.	sunset twilight	11366.tif(1:1) Kites on Bricks
31.	uranium radium	111013.tif(1:1) Kid's Blocks
32.	paranoia insane	023.tif(1:1) Wheat Stalk

Retrieval List A

	Word Pair	Context	Encoding Number & Background
1.	kerosene gasoline	same	325.tif(1:1) Airline
2.	azalea blossom	same	175.tif(1:1) Vineyard thru Trees
3.	guitar rhythm	different	006.tif(1:1) Calla Lily Foliage
4.	kingdom princess	different	119.tif(1:1) Cloverleaf Highway
5.	bookbag knapsack	same	160.tif(1:1) Construction
6.	anthill aardvark	different	IV016.tif(1:1) Mt. St. Helens
7.	cookie spatula	different	003.tif(1:1) San Francisco Sky
8.	cemetery zombie	different	111007.tif(1:1) Chainlink Fence
9.	auction antique	same	279.tif(1:1) Lighthouse
10.	paranoia insane	same	023.tif(1:1) Wheat Stalk
11.	swimmer undertow	different	034.tif(1:1) Sunset from Mt Pass
12.	chimney bricks	same	11251.tif(1:1) Fireworks
13.	runway airport	same	283.tif(1:1) Seattle Skyline
14.	blanket flannel	different	106.tif(1:1) Satellite Antennas
15.	warranty repair	different	11275.tif(1:1) Barn and Windmill
16.	painting mosaic	same	015.tif(1:1) Lone Tree
17.	income taxpayer	same	404.tif(1:1) Telephone Poles
18.	washbowl bathroom	same	11237.tif(1:1) Tulips in Vase
19.	quartet singers	different	11107.tif(1:1) Roses in the Rain
20.	sheriff handcuff	same	091.tif(1:1) Endgrain
21.	uranium radium	different	004.tif(1:1) Budded Poppy
22.	nutmeg eggnog	same	020.tif(1:1) Poppies and Lupin
23.	sapphire necklace	different	214.tif(1:1) Sprinkler Array
24.	sunset twilight	same	11366.tif(1:1) Kites on Bricks
25.	fabric scissors	same	287.tif(1:1) Lightning III

26.	inferno volcano	different	11120.tif(1:1) Tulips in Sun
27.	pavement driveway	same	122.tif(1:1) Washington Sunset
28.	recline armchair	different	111013.tif(1:1) Kid's Blocks
29.	headache stress	different	111101.tif(1:1) Sugauro Cactus
30.	pharaoh mummies	same	111015.tif(1:1) Water Lilies
31.	muscles athlete	different	305.tif(1:1) Moon
32.	fireman hydrant	different	111075.tif(1:1) Beech Trees

Retrieval List B

	Word Pair	Context	Encoding Number & Background
1.	guitar rhythm	same	119.tif(1:1) Cloverleaf Highway
2.	kingdom princess	same	11107.tif(1:1) Roses in the Rain
3.	kerosene gasoline	different	023.tif(1:1) Wheat Stalk
4.	azalea blossom	different	11366.tif(1:1) Kites on Bricks
5.	anthill aardvark	same	034.tif(1:1) Sunset from Mt Pass
6.	bookbag knapsack	different	160.tif(1:1) Construction
7.	auction antique	different	325.tif(1:1) Airline
8.	paranoia insane	different	287.tif(1:1) Lightning III
9.	cookie spatula	same	IV016.tif(1:1) Mt. St. Helens
10.	cemetery zombie	same	111075.tif(1:1) Beech Trees
11.	chimney bricks	different	175.tif(1:1) Vineyard thru Trees
12.	swimmer undertow	same	003.tif(1:1) San Francisco Sky
13.	blanket flannel	same	214.tif(1:1) Sprinkler Array
14.	runway airport	different	020.tif(1:1) Poppies and Lupin
15.	painting mosaic	different	279.tif(1:1) Lighthouse
16.	warranty repair	same	006.tif(1:1) Calla Lily Foliage
17.	quartet singers	same	111101.tif(1:1) Sugauro Cactus
18.	muscles athlete	same	004.tif(1:1) Budded Poppy
19.	income taxpayer	different	091.tif(1:1) Endgrain
20.	sapphire necklace	same	11275.tif(1:1) Barn and Windmill
21.	washbowl bathroom	different	404.tif(1:1) Telephone Poles
22.	inferno volcano	same	111007.tif(1:1) Chainlink Fence
23.	sheriff handcuff	different	015.tif(1:1) Lone Tree
24.	recline armchair	same	11120.tif(1:1) Tulips in Sun
25.	headache stress	same	305.tif(1:1) Moon

26.	nutmeg eggnog	different	11237.tif(1:1) Tulips in Vase
27.	uranium radium	same	111013.tif(1:1) Kid's Blocks
28.	sunset twilight	different	283.tif(1:1) Seattle Skyline
29.	fabric scissors	different	122.tif(1:1) Washington Sunset
30.	fireman hydrant	same	106.tif(1:1) Satellite Antennas
31.	pavement driveway	different	111015.tif(1:1) Water Lilies
32.	pharaoh mummies	different	11251.tif(1:1) Fireworks

Fragment Retrieval Lists

	List A	List B
1.	_ _ s o _ i _ e	_ h _ _ hm
2.	_ _ o _ s _ m	_ _ i _ c _ s s
3.	_ h _ _ h m	_ _ s o _ i _ e
4.	_ _ i _ c _ s s	_ _ o _ s _ m
5.	_ n _ p s _ c _	_ a r _ v a _ _
6.	_ a r _ v a _ _	_ n _ p s _ c _
7.	_ p _ t u _ _	a n _ _ _ u e
8.	z _ _ b i _	_ _ s a n _
9.	a n _ _ _ u e	_ p _ t u _ _
10.	_ _ s a n _	z _ _ b i _
11.	u _ _ e _ t _ w	b_i c _ _
12.	b _ i c _ _	u _ _ e _ t _ w
13.	_ i _ p _ _ t	f l _ _ _ _ l
14.	f l _ _ _ _ l	_ i _ p _ _ t
15.	_ e _ a _ r	_ o _ a _ c
16.	_ o _ a _ c	_ e _ a _ r
17.	_ _ x _ a y _ r	s i _ g _ r _
18.	_ a t _ _ _ o m	_ _ h l _ _ e
19.	s i _ g _ r _	_ _ x _ a y _ r
20.	_ a _ d c _ _ f	_ e _ k _ _ c e
21.	r _ _ i _ m	_ a t _ _ _ o m
22.	_ g _ n o _	_ _ l c _ _ o
23.	_ e _ k _ _ c e	_ a _ d c _ _ f
24.	t w _ _ i _ _ t	a _ m c _ _ i _
25.	_ c _ s _ o _ s	_ t r _ s _

26. _ _ l c _ _ o
27. _ r _ v _ w _ y
28. a _ m c _ _ i _
29. _ t r _ s _
30. m _ _ m _ e s
31. _ _ h l _ _ e
32. _ y d _ _ n _

26. _ g _ n o _
27. r _ _ i _ m
28. t w _ _ i _ _ t
29. _ c _ s _ o _ s
30. _ y d _ _ n _
31. _ r _ v _ w _ y
32. m _ _ m _ e s

Background Recognition

	Encoding Number and Background	Background Status
1.	048.tif(1:1) Twin Bridges	new
2.	347.tif(1:1) Railroad Tracks	new
3.	287.tif(1:1) Lightning III	old
4.	008.tif(1:1) Bracken Fern Leaves	new
5.	004.tif(1:1) Budded Poppy	old
6.	IV016.tif(1:1) Mt. St. Helens	old
7.	337.tif(1:1) Bridge at Sunset	new
8.	279.tif(1:1) Lighthouse	old
9.	178.tif(1:1) Corn Field	new
10.	015.tif(1:1) Lone Tree	old
11.	057.tif(1:1) Spring Flowers	new
12.	111040.tif(1:1) Holland Tulips	new
13.	006.tif(1:1) Calla Lily Foliage	old
14.	011.tif(1:1) Prickly Pear Cactus	new
15.	034.tif(1:1) Sunset from Mt Pass	old
16.	352.tif(1:1) NYC Skyline	new
17.	11107.tif(1:1) Roses in the Rain	old
18.	061.tif(1:1) Daises	new
19.	11366.tif(1:1) Kites on Bricks	old
20.	023.tif(1:1) Wheat Stalk	old